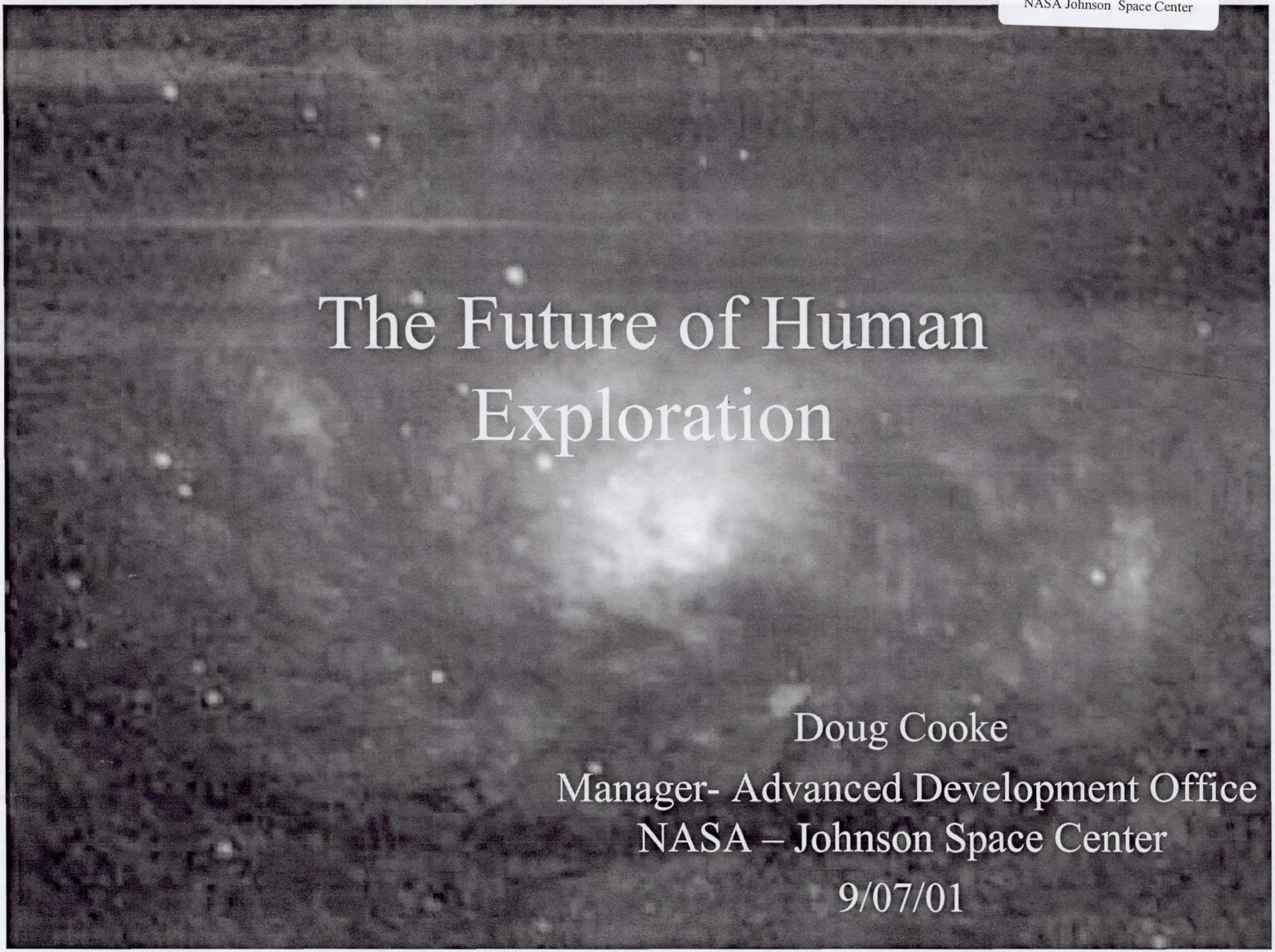
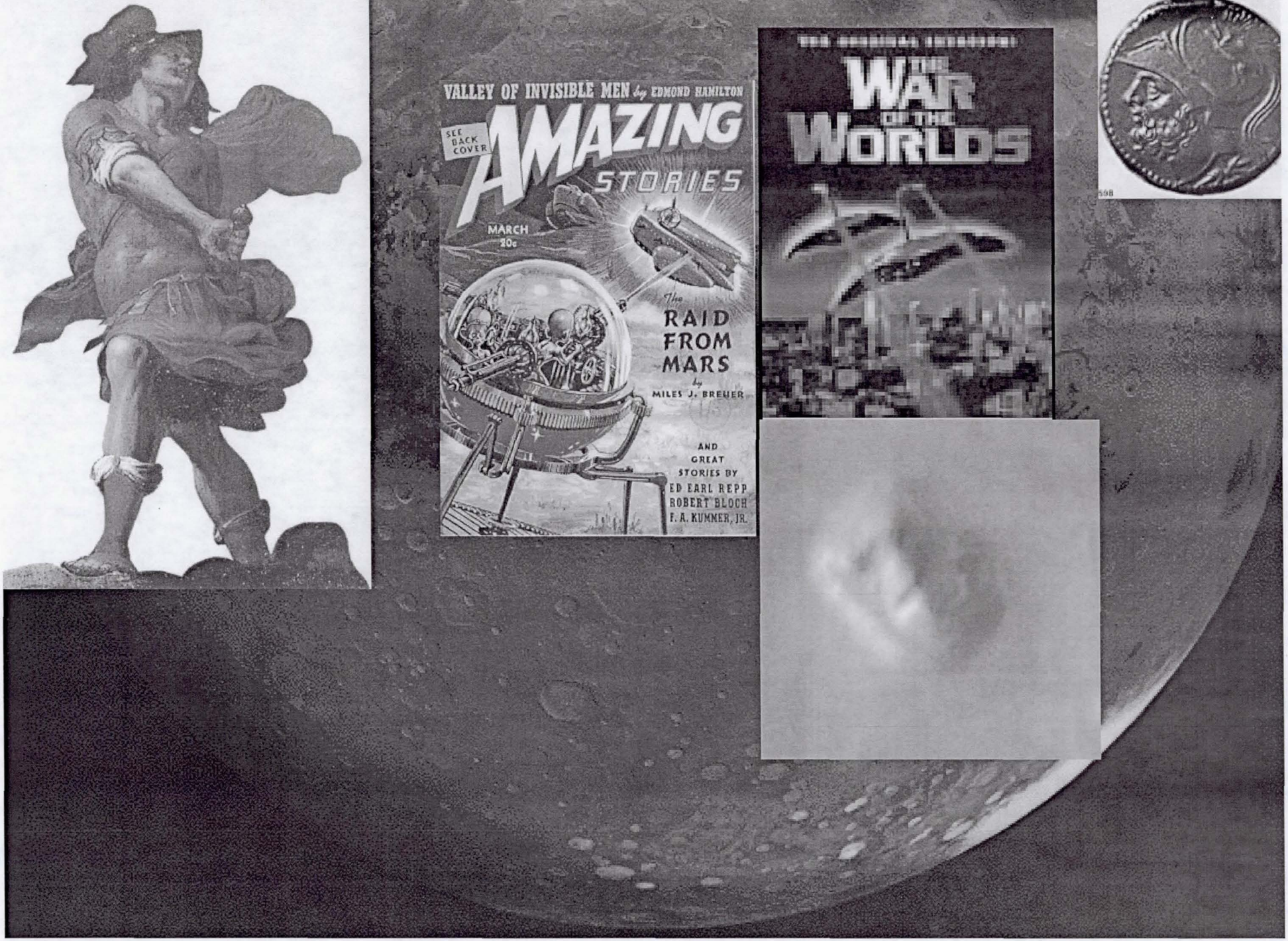


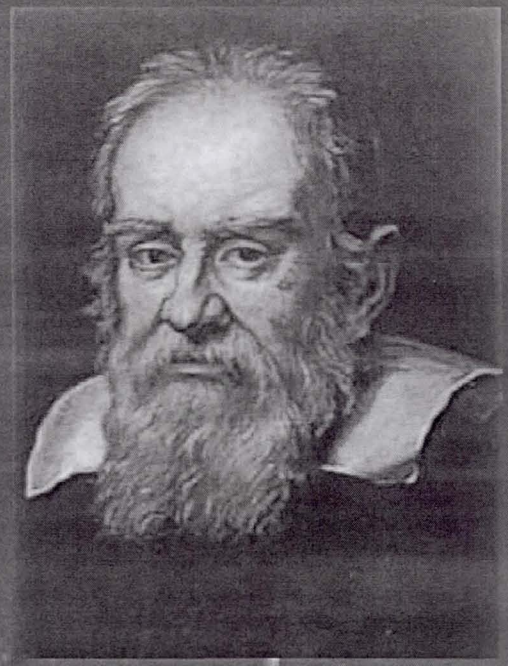
The Future of Human Exploration

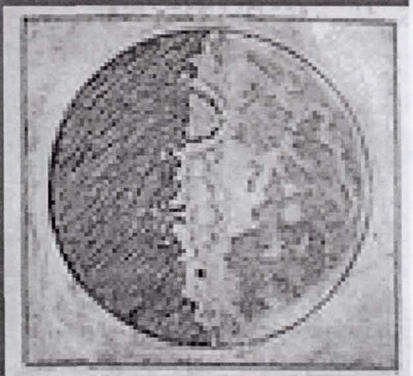
Doug Cooke
Manager- Advanced Development Office
NASA – Johnson Space Center

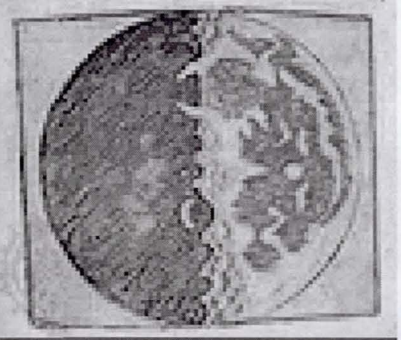
9/07/01

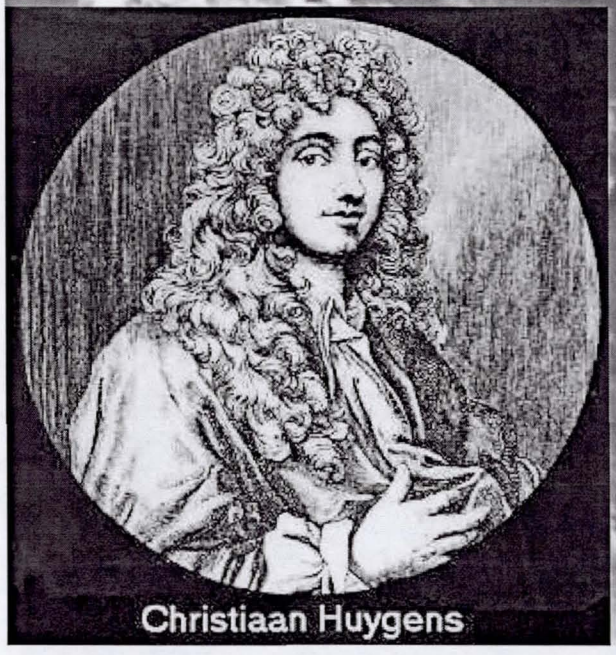

VALLEY OF INVISIBLE MEN by EDMOND HAMILTON
SEE BACK COVER
AMAZING STORIES
MARCH
20c
The RAID FROM MARS
by MILES J. BREUER
AND GREAT STORIES BY
ED EARL REPP
ROBERT BLOCH
F. A. KUMMER, JR.
THE ORIGINAL INVASION!
THE WAR OF THE WORLDS

Galileo
1609

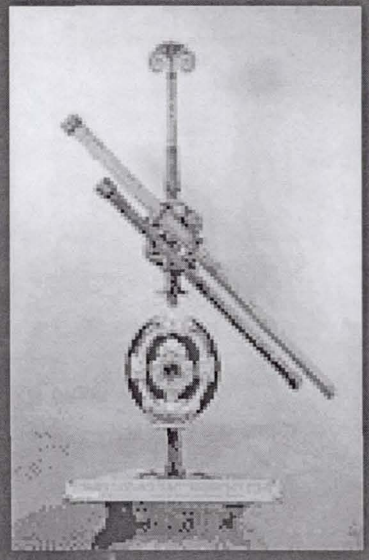




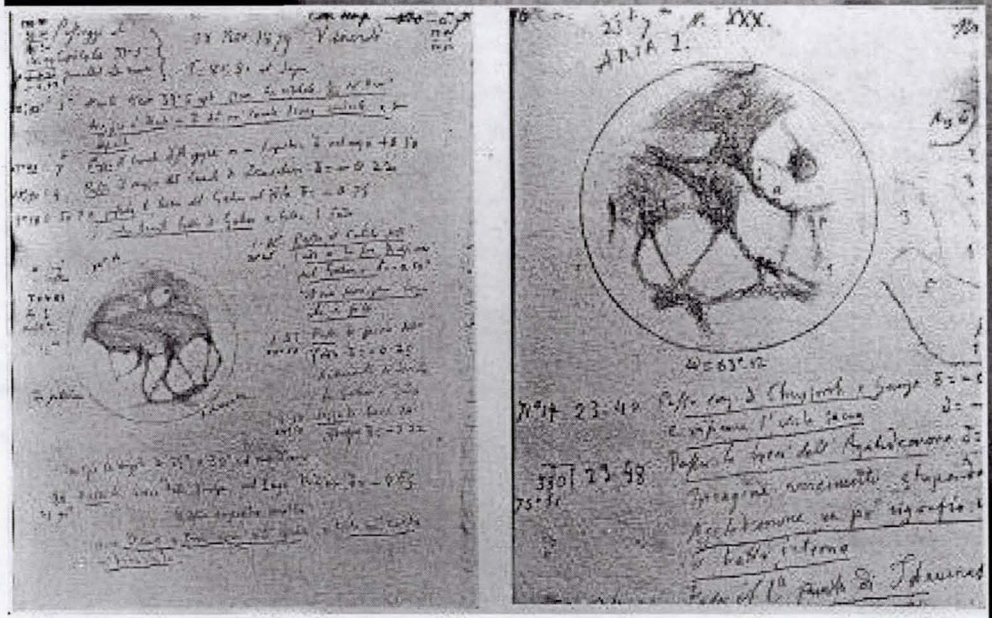




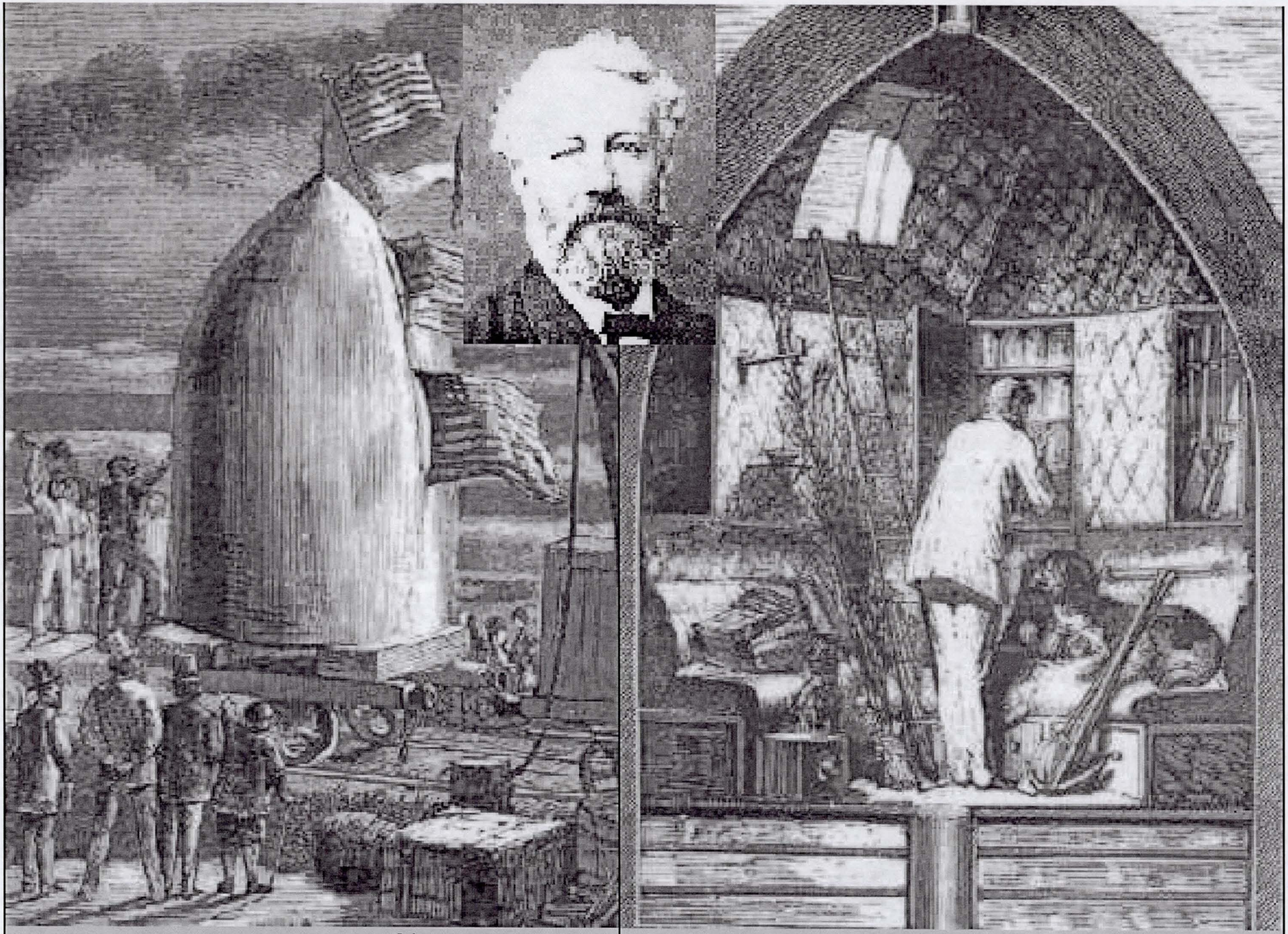
Christiaan Huygens



Giovanni Virginio Schiaparelli

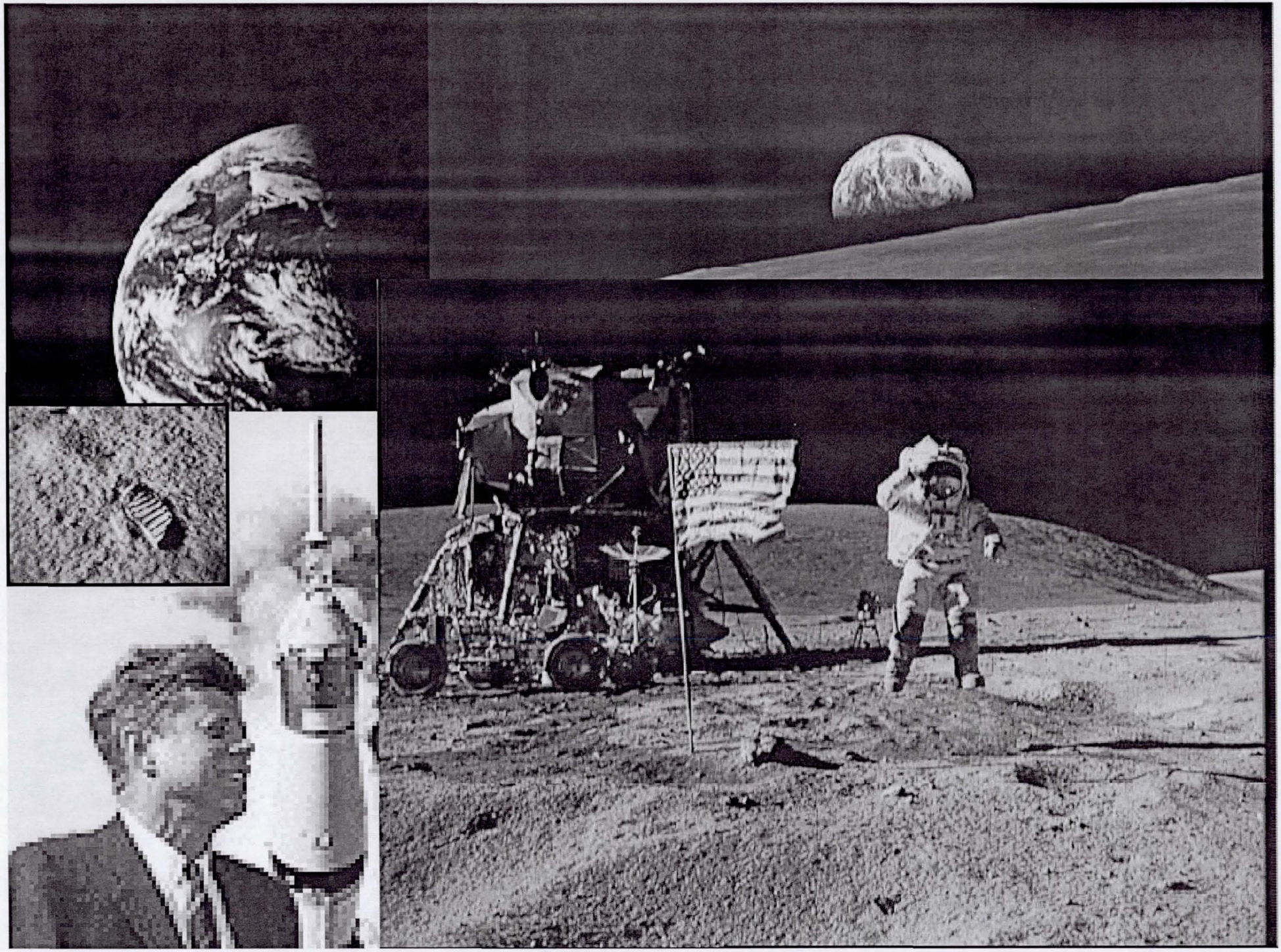


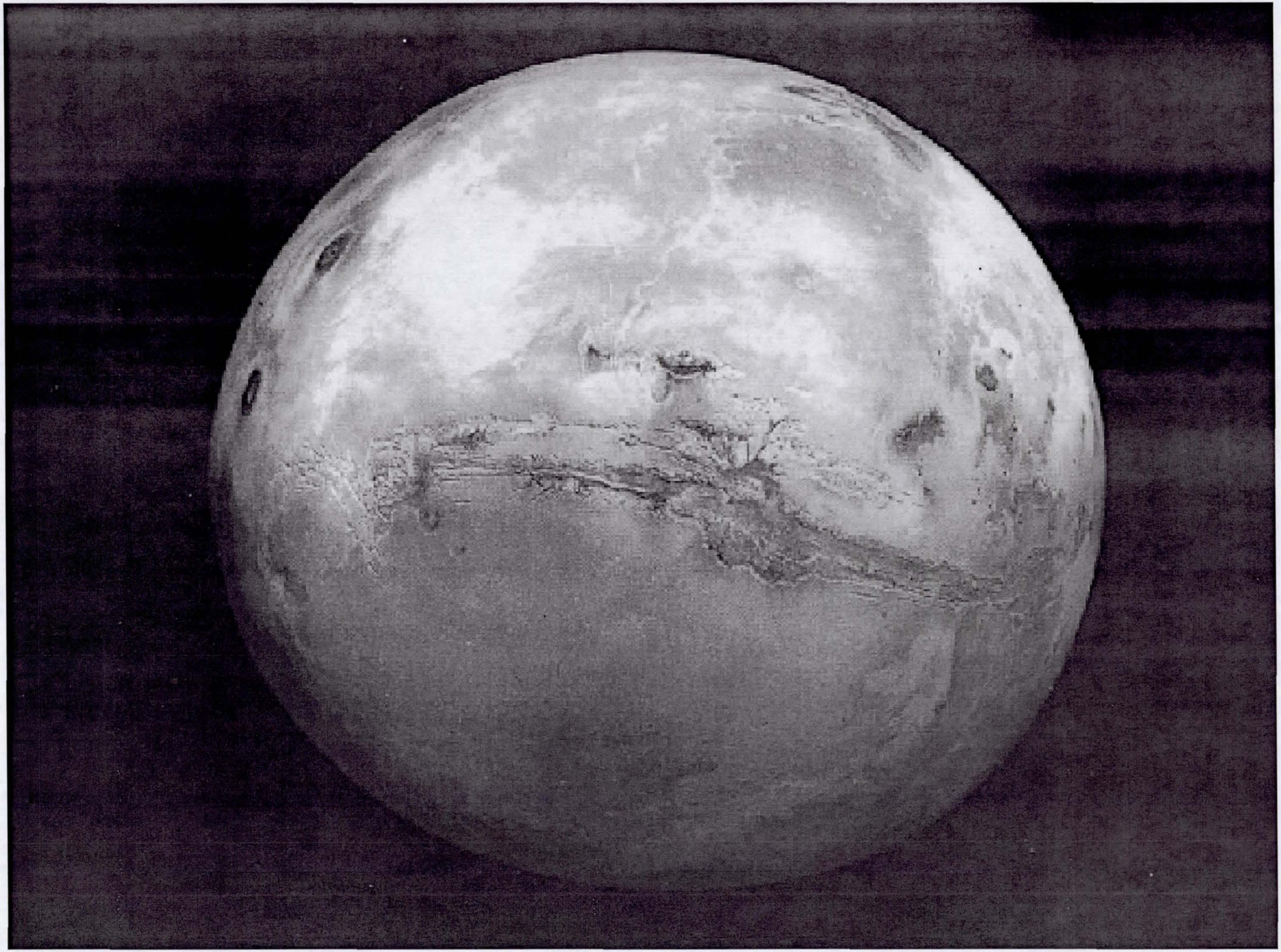
Pages from Schiaparelli's observing notebook, 1879

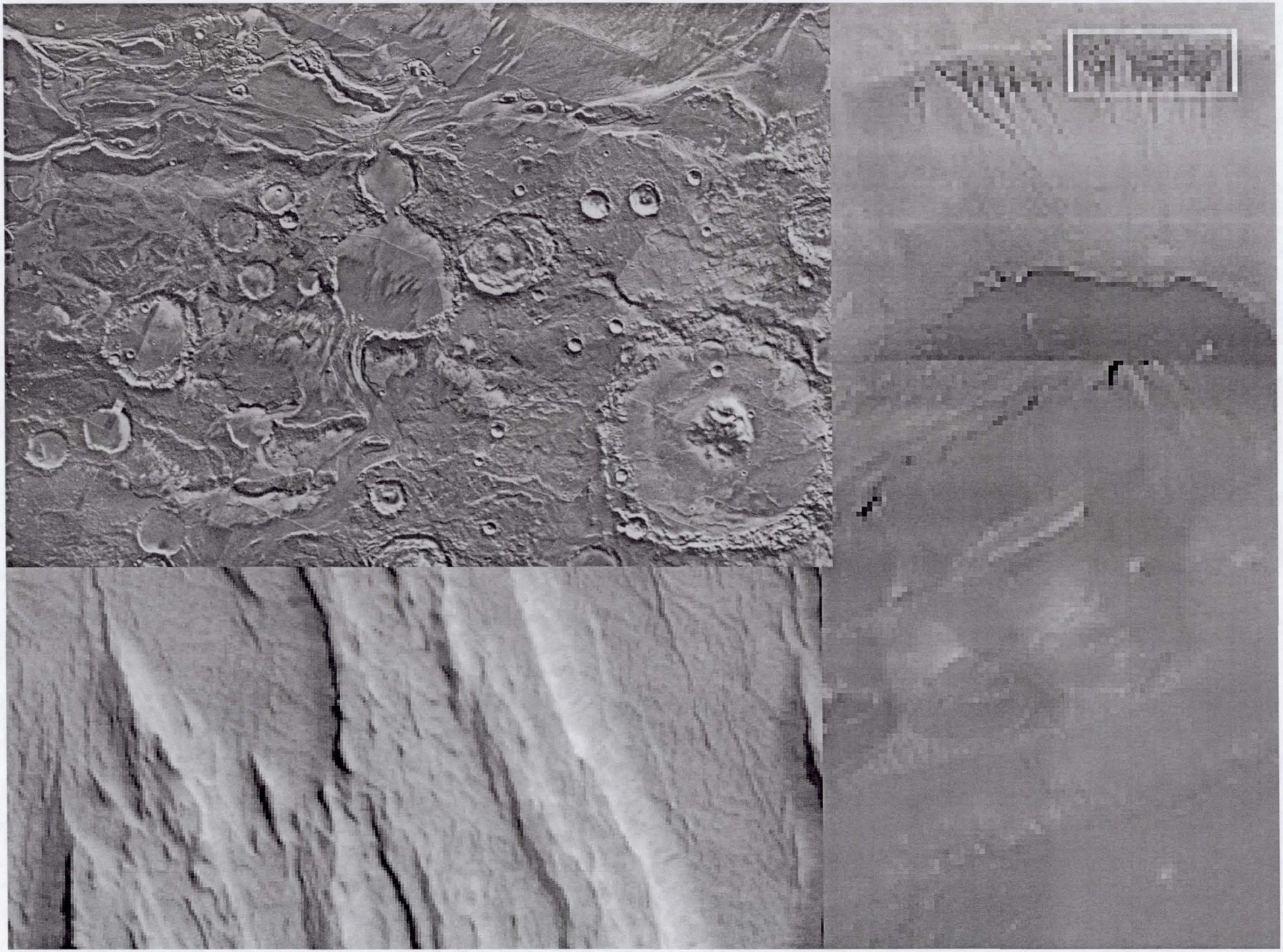


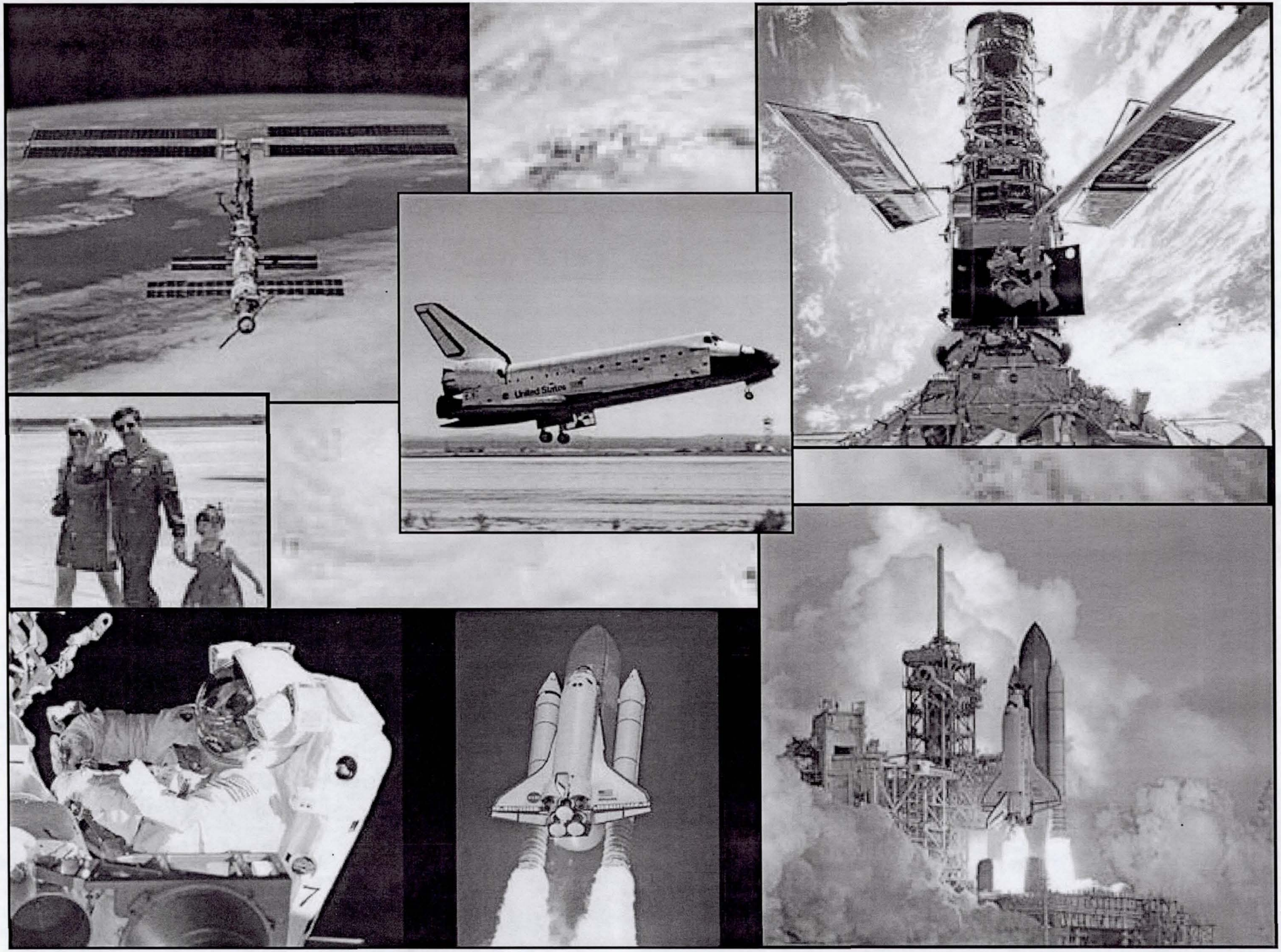
verne_moon2.jpg

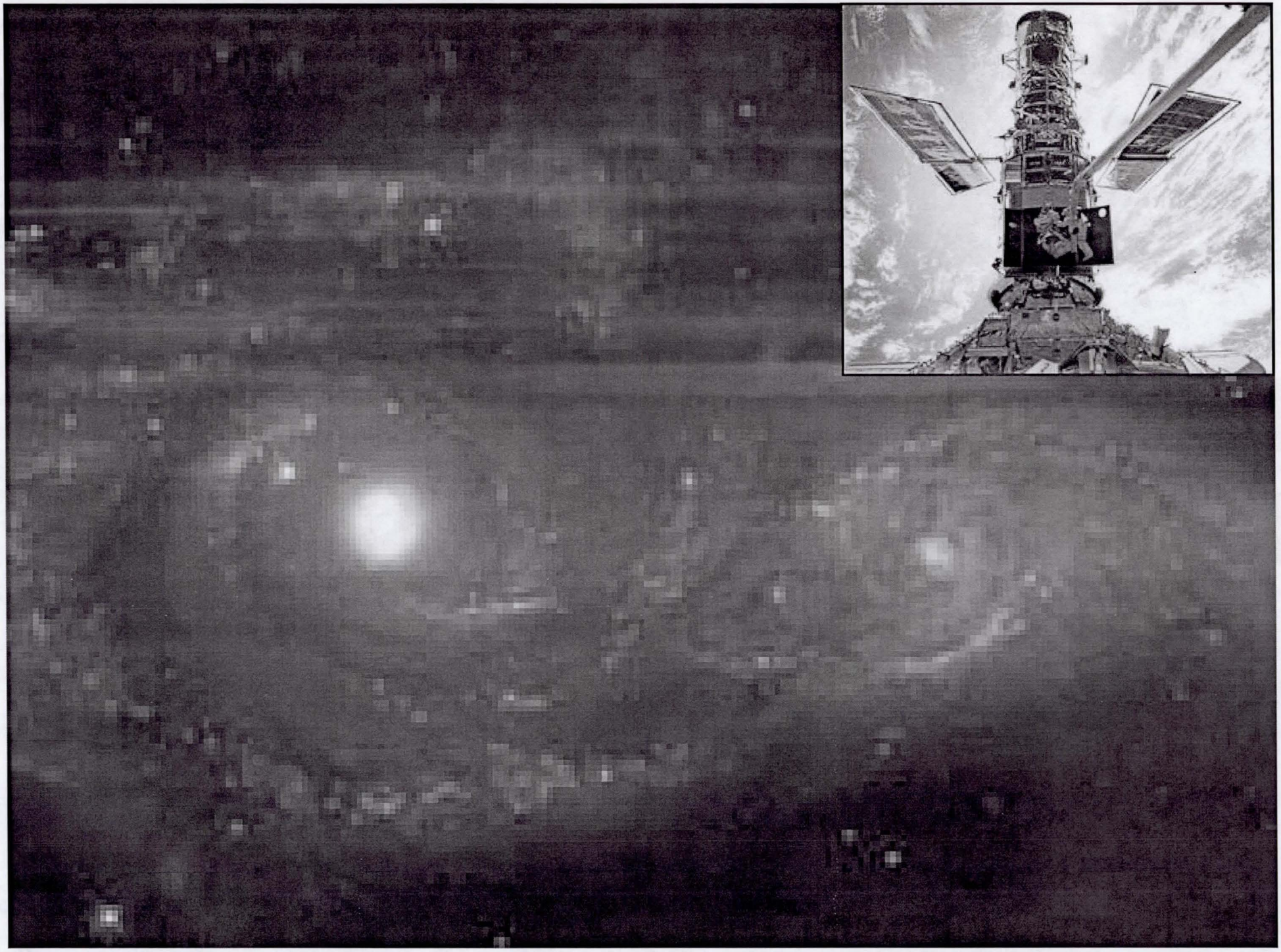
verne_moon1.jpg

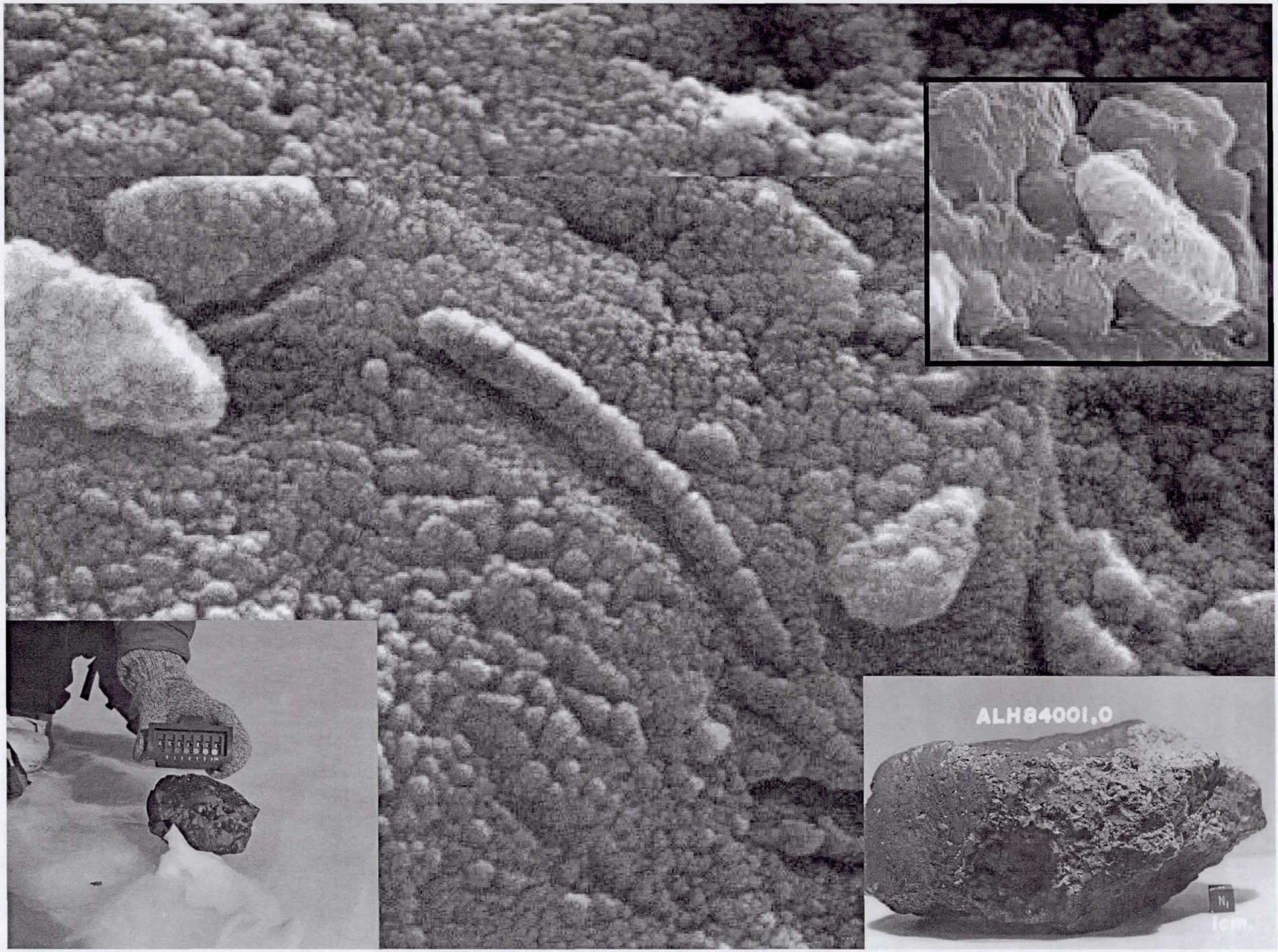








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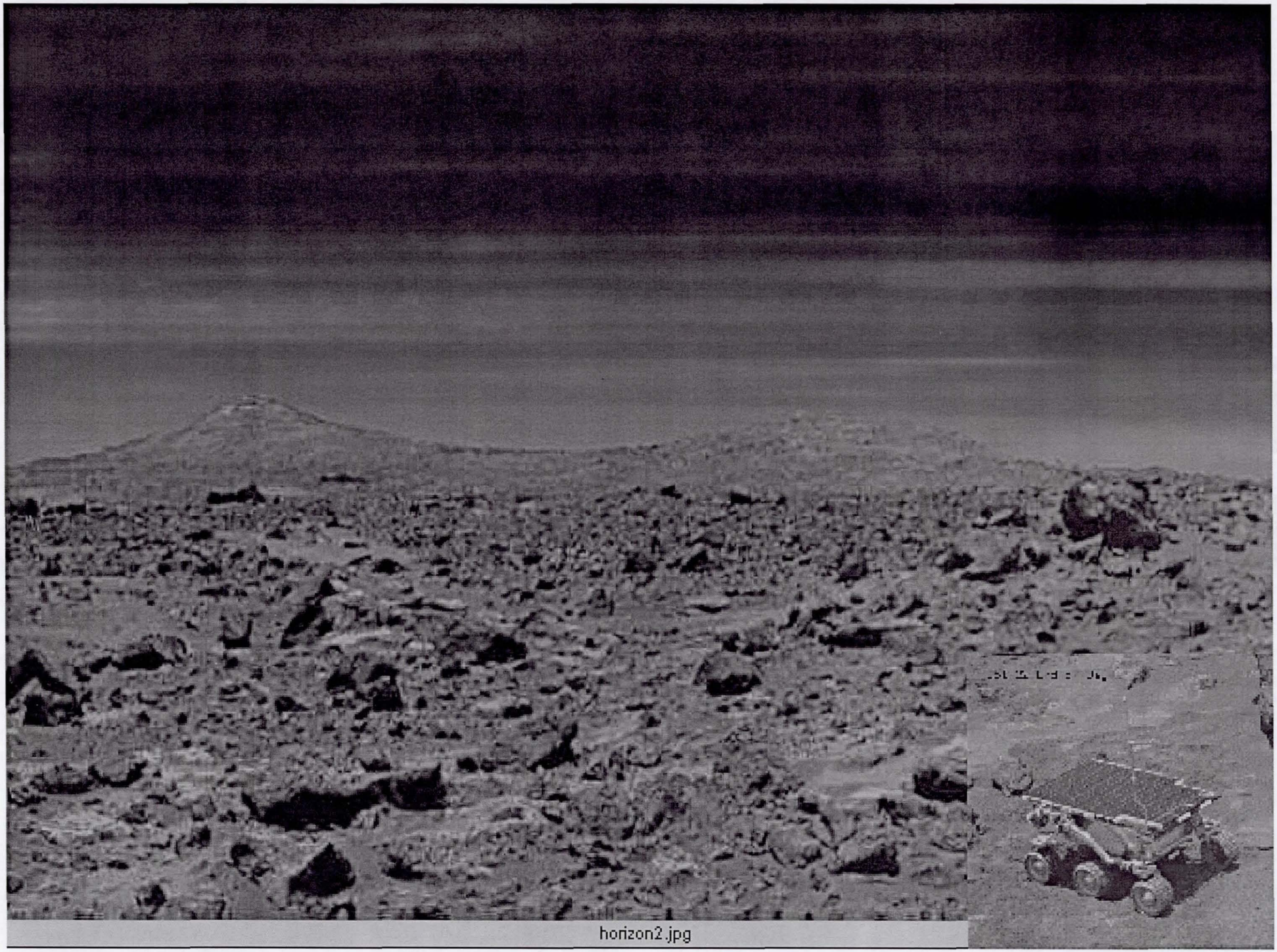
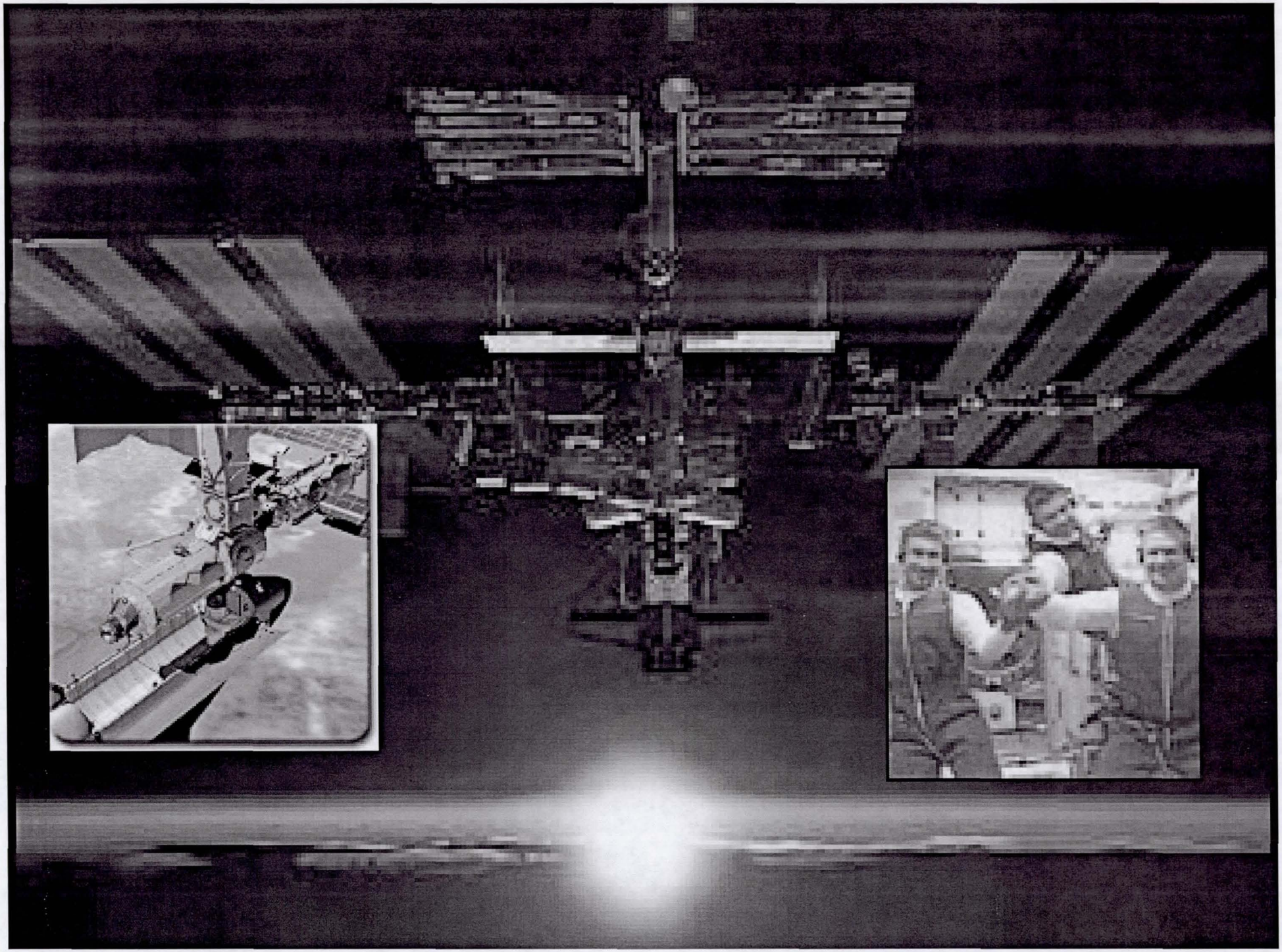
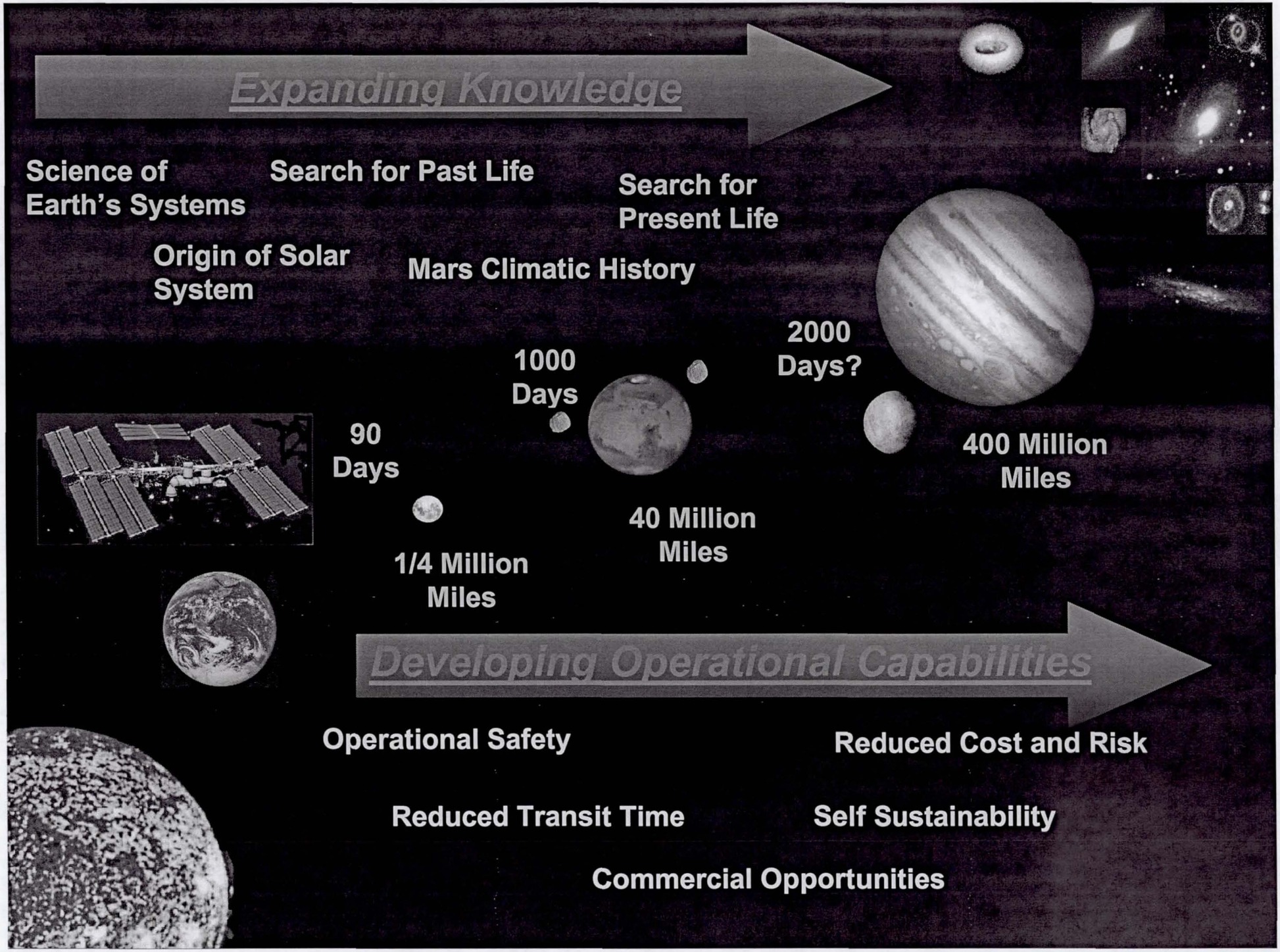


horizon2.jpg




Expanding Knowledge
Science of Earth's Systems
Search for Past Life
Search for Present Life
Origin of Solar System
Mars Climatic History
2000 Days?
1000 Days
90 Days
400 Million Miles
40 Million Miles
1/4 Million Miles
Developing Operational Capabilities
Operational Safety
Reduced Cost and Risk
Reduced Transit Time
Self Sustainability
Commercial Opportunities

Core Capabilities & Technologies

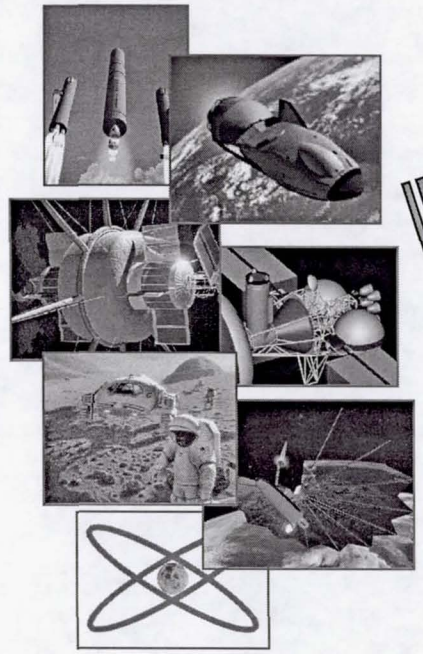
Common Technology Building Blocks (Core Technologies)	*Common System Building Blocks (Core Capabilities)*	*Potential Destinations*

Examples

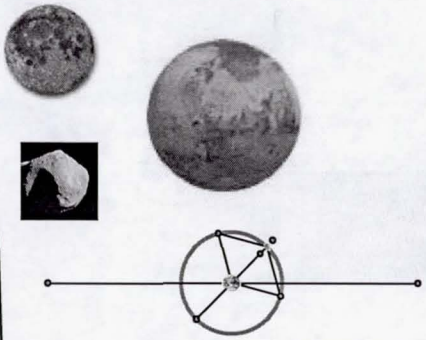
- Efficient In-Space Prop..
- Aeroassist
- Low-cost Engines
- Cryo Fluid Management
- Robust/Efficient Power
- Lightweight structures
- Radiation Research
- Zero/Low-g Research
- Regenerable Life Support
- Advanced Lightweight EVA

- "Breakthrough" Technologies

System Design

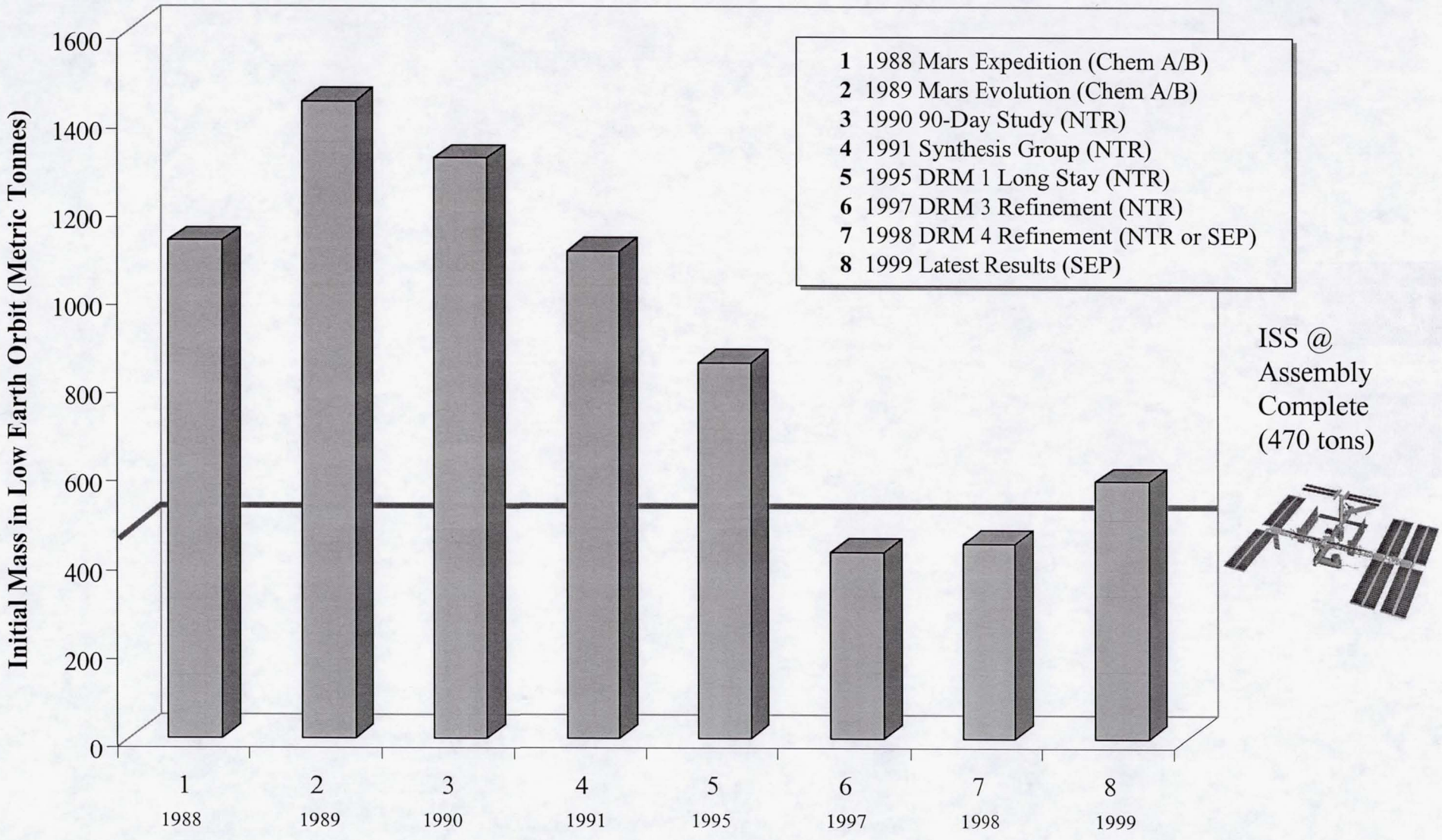


Mission Analyses



2/12/01

Mars Architecture Mass Comparison



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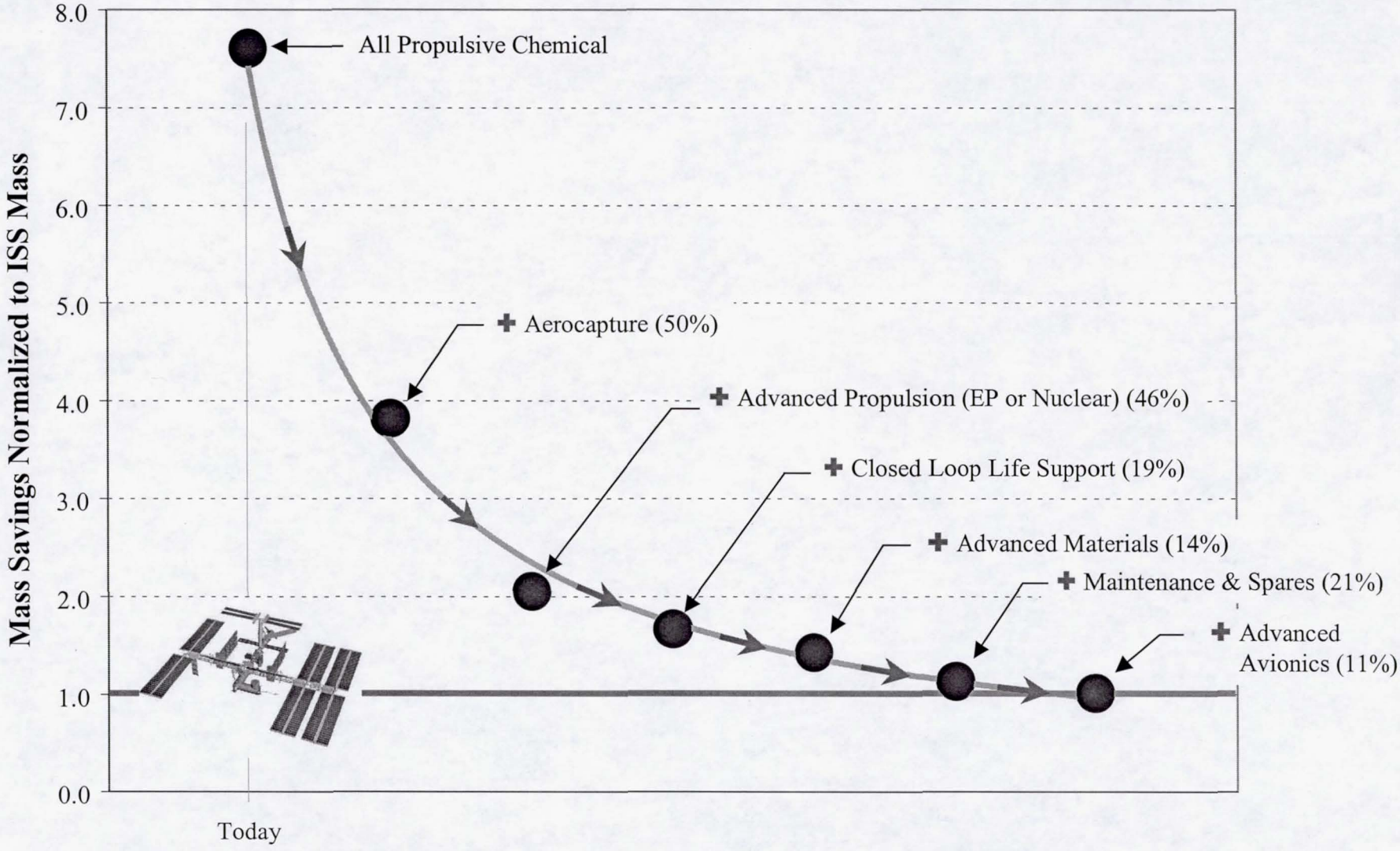
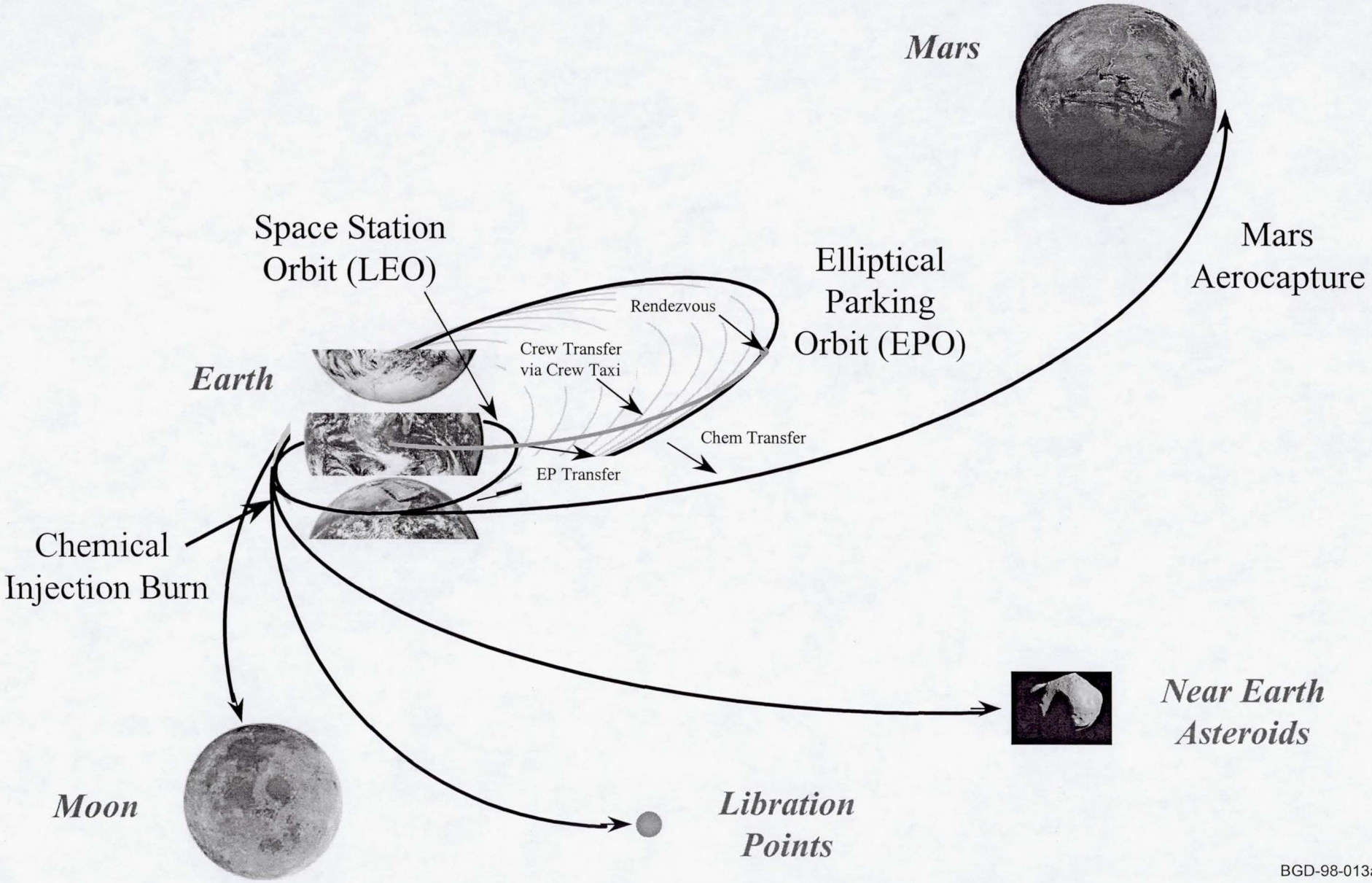
The Value of Technology Investments
Mars Mission Example



High Earth Orbit Staging Mission Scenarios



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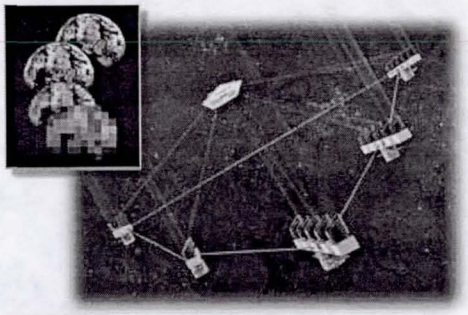
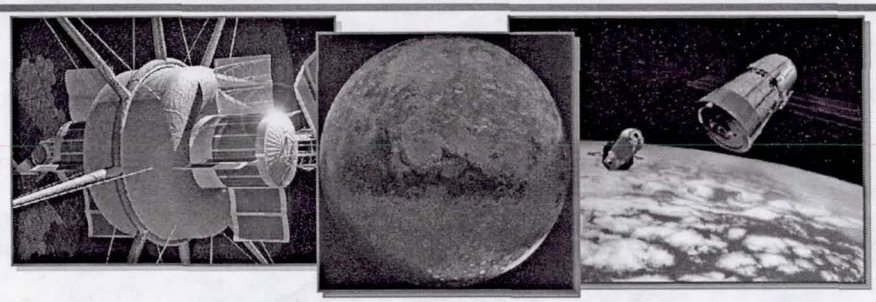
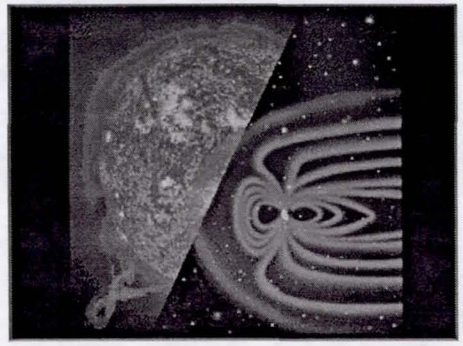




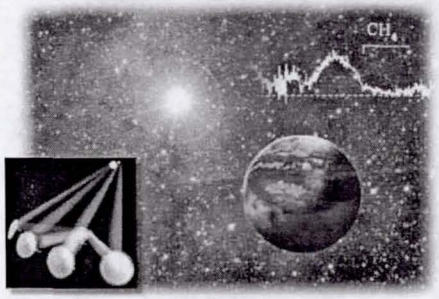
Human Mars Exploration

- Technology Development
- Deep-Space Operational Experience
- Mission Staging (Hybrid Prop Module Fuel Depot)



Construct and Deploy Solar Sentinels

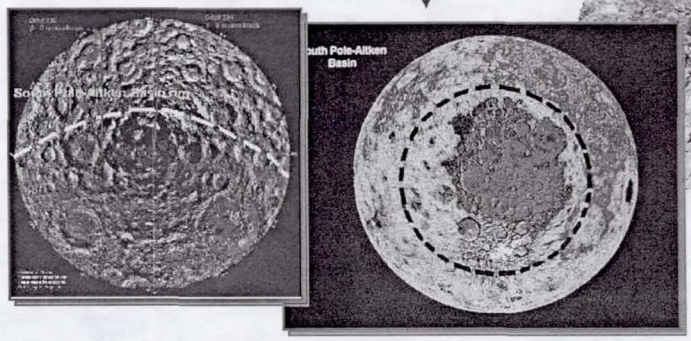
- Search for Location and Mechanism of Solar Flares
- Increase Lead Time and Accuracy for Geospace Forecasts

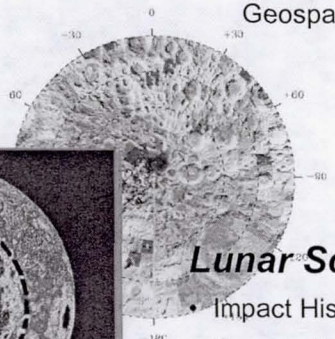


Construct, Deploy, and Service Advanced Astronomical Instruments

- Detect Biological Activity on Extra-Solar Planets
- Image Surfaces of Extra-Solar Planets

"Earth's Neighborhood" Capabilities

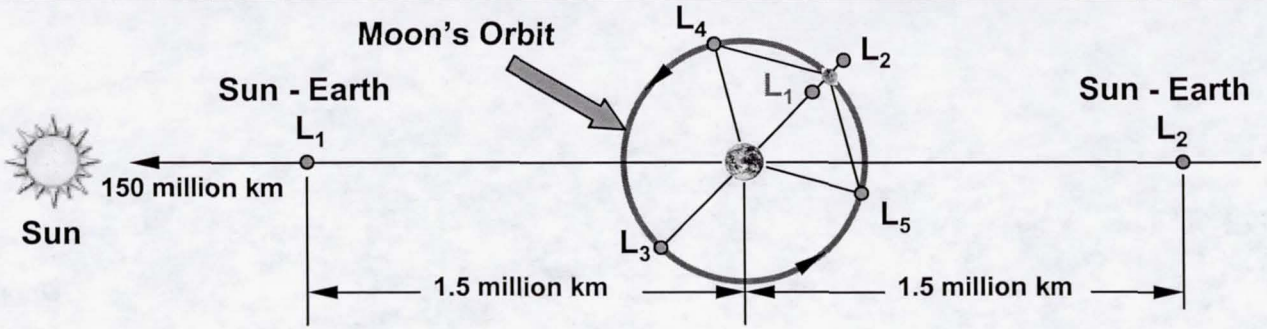


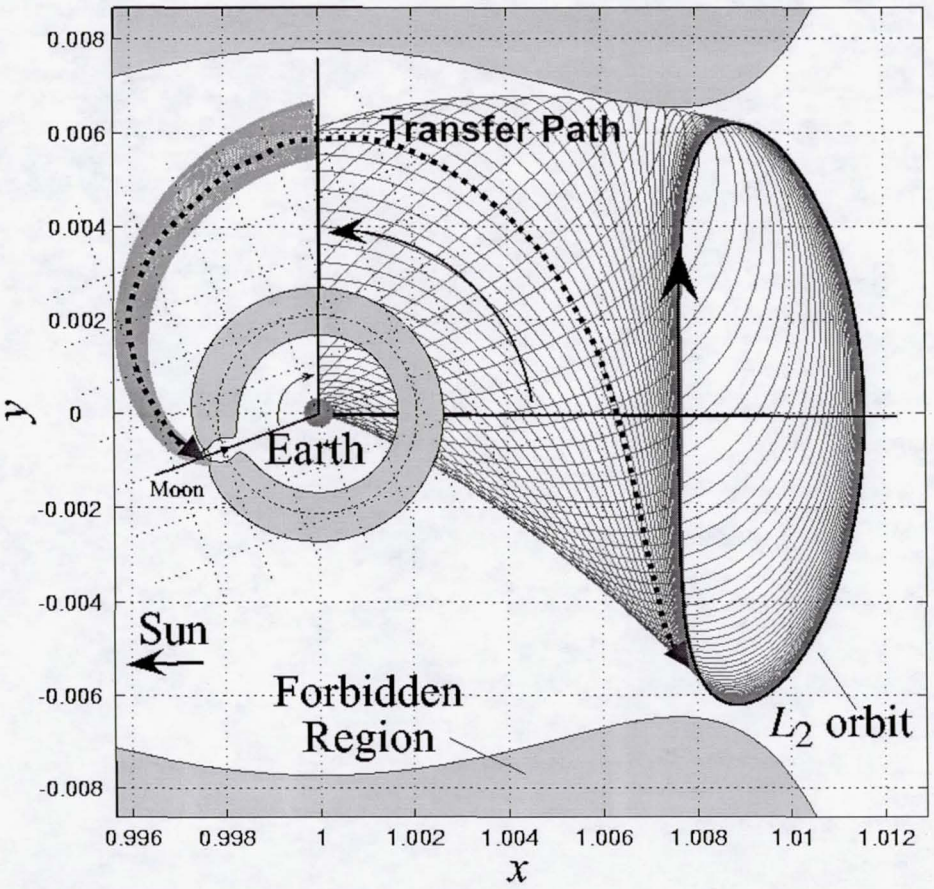


Lunar Science

- Impact History in Near-Earth Space
- Composition of Lunar Mantle
- Past and Current Solar Activity
- Poles - History of Volatiles in Solar System

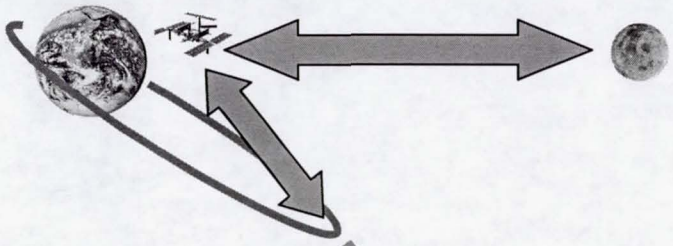
Unique Orbital Dynamics





- Orbital Dynamics in Earth-Moon System Leads to Unique Capabilities
  - Low-Energy Transfer from Earth-Moon L1 to Solar Libration Points and Return
  - Potential Staging Point for Human Mars Missions
- Allows for Earth-Moon L1 Deployment and Servicing of Science Assets

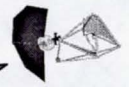
Architecture Evolution



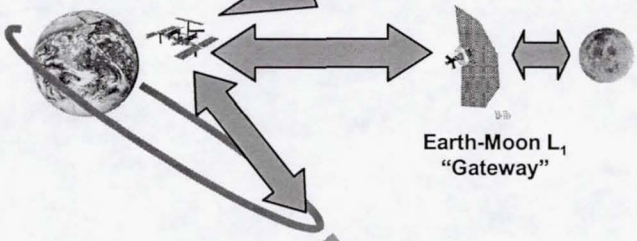
High Earth Orbit

Mars

- **Common Technologies**
  - Solar Electric Propulsion
  - Habitation Systems
  - Crew Transportation
  - Advanced EVA



Earth-Sun L_2 "Gateway"

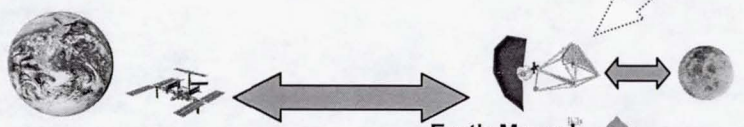


Earth-Moon L_1 "Gateway"

High Earth Orbit

Mars

- **Unique Orbital Dynamics**
  - Human Activities at Earth-Moon L1
  - Remote Delivery, Retrieval of Science Instruments



Earth-Sun L_2

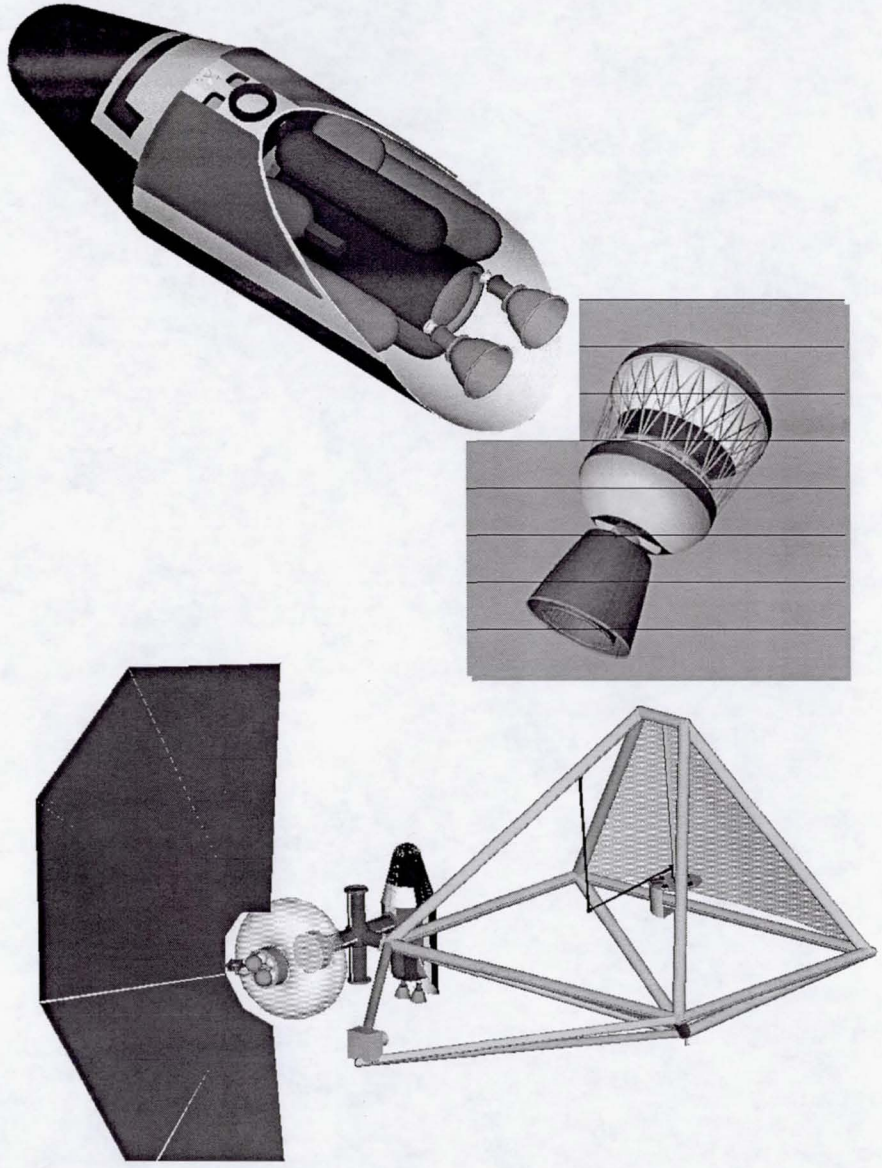
Earth-Moon L_1 "Gateway"

Mars

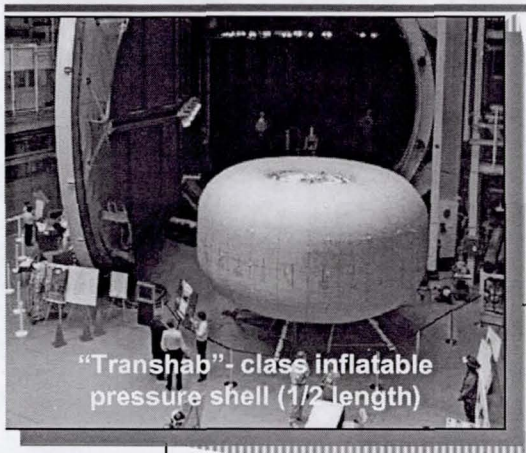
Earth's Neighborhood, Libration Points Architecture

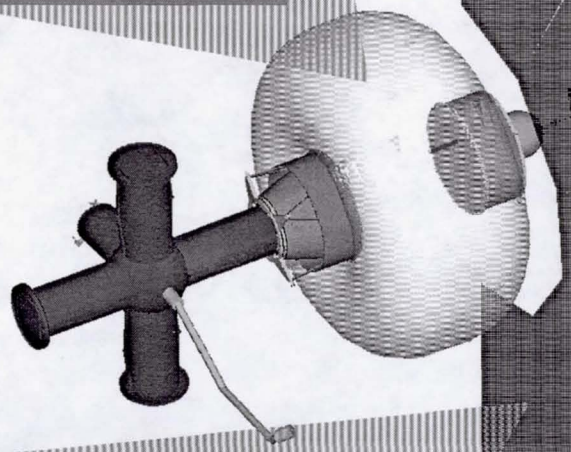
Key Attributes

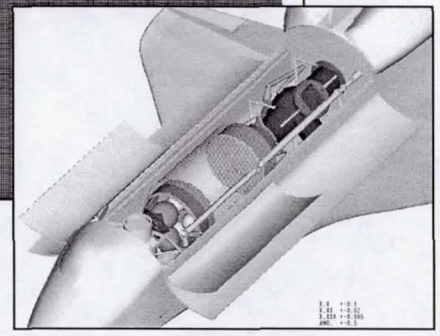
- Crew of 4
- 65 day mission duration
- Deployment, assembly, and servicing of large complex science facilities to achieve revolutionary discoveries
- ISS integral as a staging platform
- Serves as a "stepping stone" by providing an opportunity to test technology and operational concepts, reducing risk of future exploration endeavors
- Architecture can be bought "by the yard" resulting in increasing capabilities and operational experience
- Modest augmentation of commercial launch vehicles
- Common architecture elements for all Earth's Neighborhood missions



Lunar L_1 "Gateway"



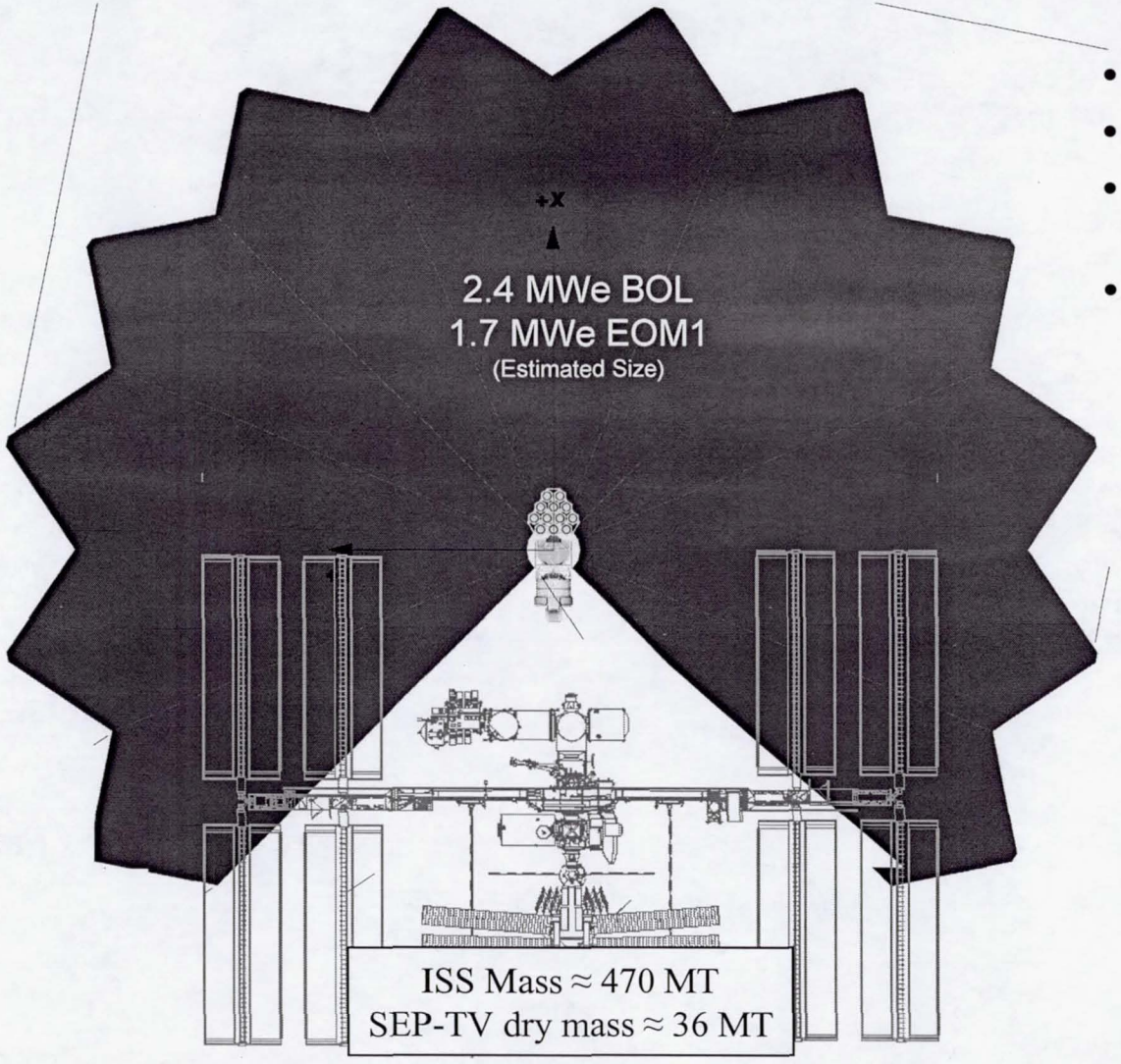




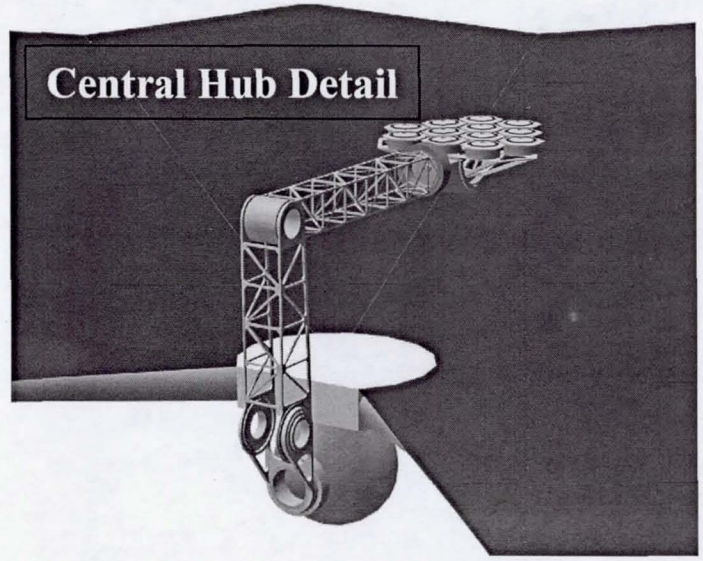
Key Attributes

- Crew of 4
- Global lunar access – 3 day
- Lunar polar outpost – 30 days
- ISS integral as a staging platform
- Lunar missions serve as "stepping stones" by providing an opportunity to test technology and operational concepts, reducing risk of future exploration endeavors
- Architecture can be bought "by the yard" resulting in increasing capabilities and operational experience
- Modest augmentation of commercial launch vehicles
- Common architecture elements for all Earth's Neighborhood missions

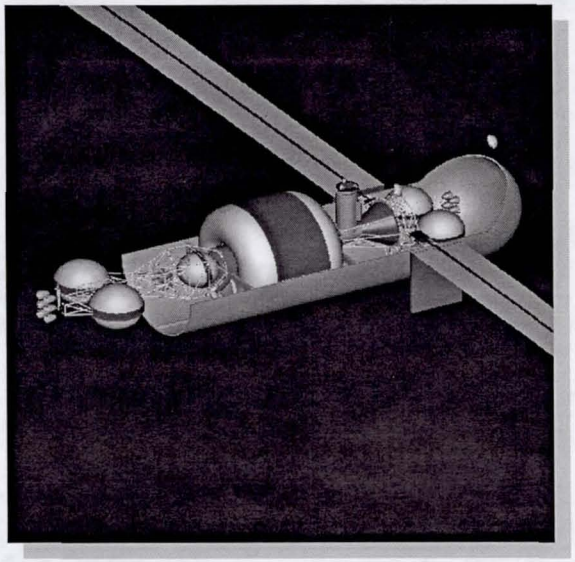
Solar Electric Propulsion Concept



- Array sized to provide 1700 kW_e throughout first mission
- 14700 m^2 $CuInS_2$ array area
- 171 m span (wingtip-wingtip)
- 17 x 100 kW_e Hall Thruster Propulsion
- Articulated boom thruster gimballing

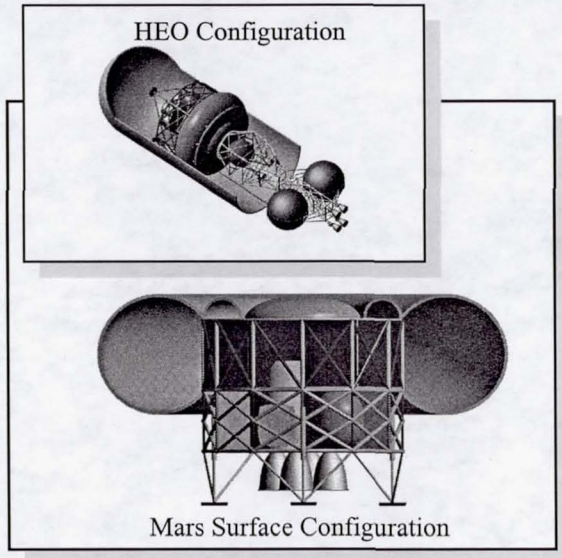


Mars Mission Vehicle Concepts



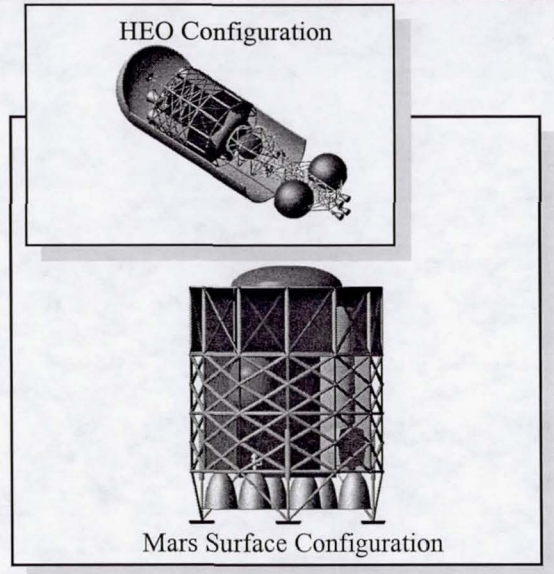
Mars Transit Vehicle

- Supports mission crew of six for up to 200-day transits to and from Mars
- Return propulsion stage integrated with transit system
- Provides return-to Earth abort capability for up to 30 hours post-TMI
- Total Vehicle Mass in High-Earth Orbit = 188 mt



Mars Surface Habitat

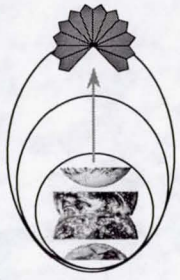
- Vehicle supports mission crew of six for up to 18 months on the surface of Mars
- Provides robust exploration and science capabilities
- Descent vehicle capable of landing 36,000 kg
- Total Vehicle Mass in High-Earth Orbit = 99 mt



Descent/Ascent Vehicle

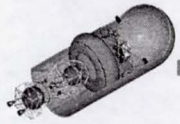
- Transports six crew from Mars orbit to the surface and back to orbit
- Provides contingency abort-to-orbit capability
- Supports six crew for 30-days
- Vehicle capable of utilizing locally produced propellants
- Total Vehicle Mass in High-Earth Orbit = 103 mt

Mars Mission Overview

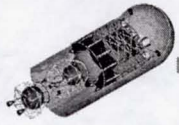


Habitat Lander and Ascent/Descent Vehicles delivered to Low Earth Orbit with Magnum. Solar Electric Propulsion stage spirals cargo to High Earth Orbit. Chemical injection used at perigee. SEP spirals back to LEO for reuse.

Surface Habitat and exploration gear aerocaptures into Mars orbit



Ascent/Descent Vehicle aerocaptures and remains in Mars orbit for the crew



Crew rendezvous with Descent/Ascent Vehicle in Mars Orbit then lands in vicinity of Habitat Lander

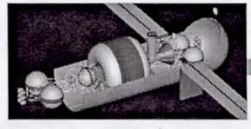
Surface Habitat lands and performs initial setup and checkout - Initial outpost established

30 days provided to satisfy "long-stay" criteria.

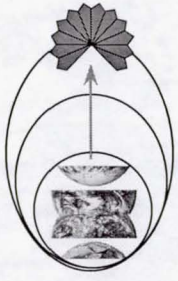
Mars Surface

Crew ascends and rendezvous with waiting Transit Habitat

Habitat remains in Mars orbit



Crew travels to Mars in "fast transit" 180-day transfer. Aerobrakes into Mars orbit



Transit Habitat vehicle delivered to LEO with Magnum. SEP spirals Transit Habitat to High Earth Orbit. Crew delivered to vehicle via crew taxi. SEP spirals back to LEO for reuse.

Crew returns to Earth on "fast transit" 180-day transfer. Direct entry at Earth

Earth Orbit

2/12/01